DEVELOPING STRATEGIES FOR QUALITY ENGINEERING EDUCATION TO MEET THE CHALLENGES OF GLOBAL COMPETENCE: A SYSTEMS APPROACH

Ph.D. SYNOPSIS

Submitted by

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Synopsis of research work intended to be carried out

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in

Pursuance of the requirements for the award of the degree of
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1. INTRODUCTION:

In context with local, national and global development engineers contribute to economical advancement, wealth generation and improvement in the human condition through the creative application of science and technology. [1]

Engineering programs are geared toward development of conceptual skills, and consist of a sequence of engineering fundamentals and design courses, built on a foundation of complex mathematics and science courses.

In April 2002, universities from Latin American countries, Portugal and Spain adopted a Declaration at the III Summit of Iberian and Latin American Universities in Porto Alegre, Brazil in which they declared education as a 'public good'. However, over-time the perception of higher education as a commercial service is gaining acceptance. [2]

World Conference on Higher Education in the Twenty-First Century: Vision and Action held at United Nations Educational Scientific and Cultural Organization (UNESCO) headquarters in Paris from October 5 to 9, 1998 was attended by nearly 5000 participants representing 180 countries. The main theme was that higher education must serve the interest of sustainable development and help build a better society. [3]

Indian Council for Research on International Economic Relations (ICRIER), a New Delhi-based think tank reports India as home to the world's largest pool of scientific and knowledge workers. It produces 400,000 engineers each year while the United States produces only 60,000. It is expected that to sustain these positive trends alongwith the economy growth at a rate of 7%, India's higher education gross enrolment ratio (GER) would need an increase. [4]

Quality of Education is a concept which is least understood, vaguely defined and not properly addressed. It contains a limited portion of the concept of the overall quality of education.
Human capital is playing an increasingly important role in the global competition along with the rapid expansion of the economic globalization. Talents have become a most important strategic resource. This fact is applicable to educational institution also because the products of most of these institutions that is the students are not meeting the initial prerequisite standards of industries. It is very much necessary that the students coming out from engineering colleges must be directly useful to industries. [5] [6]

In today's world of global competition the quality service is a key for success. The same need has been identified in universities. The identification of the dimensions which signals the quality has emerged as key issues facing the academy. [7].

The system of public education at all levels is in advanced stage of disrepair and disarray. It is needed to allocate more resources and attention on ensuring that future generations are equipped sufficiently to operate in a knowledge economy.

2. QUALITY ENGINEERING EDUCATION TOWARDS GLOBAL COMPETENCE:

Quality of education plays pivotal role in the process of development of nations. Hence, quality concerns in education are national priorities for all nations. Quality has multiple perspectives and is not a unitary concept.

Quality of an institution / a program or an educational system is generally considered on the basis of achievements of its alumni. Engineering education system is not devoid of this fact. Various factors that affect quality are finance, sincerity of students and faculty, skill of managements etc. Search for quality in higher education brought forth the concept of 'world class universities' which has become a catch phrase today not only to improve the quality of learning and research but also to develop the capacity to compete through the acquisition, adoption and creation of advanced knowledge. It is with this reason that not only developed but also developing nations have started making attempt towards creating world class universities. [8]

Although Indian government has failed to provide adequate amount of funds yet private initiatives have made education a huge industry to the extent that in certain cases the profit from educational institution is much higher than one can expect from small scale industry. [9] Commercialization of education in general and engineering education in particular is needed or not, is a matter of debate and consensus. However, the following statement made by the Honorable Supreme Court of India is worth mentioning. It speaks, "Education has never been commerce in this country. Making it one is opposed to the ethos, tradition and sense of this nation."[9]

Global competence is, therefore, essential for engineers to compete in an international market for engineering know-how. Engineering profession requires significant inter-cultural skills in order to join efficient and productive collaborations with diverse engineering colleagues.

The quality is defined by British Standards Institution, 1978 as "the totality of features and characteristic of a product or service that bear on its ability to satisfy stated or implicit needs". [10]

The US National Science Foundation (NSF) task force on TQM has come up with the definition of Quality Engineering Education as the development of intellectual skills and knowledge that will equip graduates to contribute to society through productive and satisfying engineering careers as innovators, decision-makers and leaders in the global economy of the twenty-first century. [11]

Parliamentary Standing Committee on HRD in its report has recommended that the issue of quality and excellence of higher education including engineering education as well should be given more importance in India. Academic ambience in our universities / institution needs improvement. Quality and excellence are the watch-words in today's liberalized environment. [12]

Quality involves continuous improvement and also implies zero defects or errors. The scope of quality includes manufacturing activities, business processes and services, and focus on the needs of both external and internal customers. Some of the characteristics of quality applicable to the service sector are responsiveness to customer, cost-sensitivity, volume-sensitivity, ethical considerations, energetic and enthusiastic approach, and openness to experiment, goal/results focus, errors and heavy investment in training. Higher education in general and engineering education in particular being an important service providing system should consider these characteristics if it aims for global competence. It is then that the development of intellectual skills and knowledge will equip graduates to contribute to society through productive and satisfying engineering careers as innovators, decision makers and leaders in the global economy. [13], [14]

The ability of a product to satisfy the requirements of the customer and quality in engineering education is an open system at various levels i.e. students, teachers, curriculum, institutional and state level. TQM is an integrative philosophy of management for continuously improving the quality of product and processes to achieve customer satisfaction. The main philosophies of TQM include customer focus, continuous improvement and process - orientation in teaching and learning process. [15]

Total Quality Management (TQM) is an attempt to retain competitiveness in order to achieve customer satisfaction in this competitive era of globalization. TQM seeks to identify the sources of defects in order to prevent it before it enters into the final product. [16]

Education quality is important for both, those who are involved in it either directly or indirectly, and for those also who use its services. Access to quality education is to be regarded as dependent and indivisible needs. TQM approach in education involves not only achieving high quality but also influencing all segments of the educational process: namely organization, management, interpersonal relations, material and human resources, etc. Educational institutions play an important role in the development of the national economy and the society by providing high quality educational services. [17]

3. THE PARADIGM SHIFT

Today, the higher education system as well as engineering education is faced with many issues of concern like financing and management alongwith access, equity, relevance and reorientation of program by laying emphasis on values with the assessment of institutions and their accreditation. These issues are of vital importance and can be a powerful tool to build knowledge based society of the 21st century. [18]

Unemployment is an issue of concern even today. While addressing the challenges of unemployment, His Holiness Sir Sahabji Maharaj in his convocation address at Agra University once spoke that the courses provided in the institutions are misfit and require to be modified and extend to suit the needs of the time. This can be done by means of enlarging the

curricula, multiplying specialities, allowing students to have a wider choice of studies, and encouraging latest technical education. No retrograde step is required for the same. [76]
The above statement emphasises the relevance of broad based and flexible higher engineering education system to meet the challenges of unemployment. Further for such system to be worthwhile quality becomes a watch word. Speaking about the meaning of quality in higher education system including engineering education, Dr. MB Lal Sahab, Ex-Vice Chancellor of Lucknow University and a Zoologist of international eminence and the founder director of Dayalbagh Educational Institute spoke that the quality of a university is not great by its big buildings, more number of students, more number of teachers, and more number of departments but the quality of university is judged by the quality of work of its staff and students, on 10th November 1993. [76]

Recognizing this requirement, the institutions of higher learning have to perform multiple roles like creating new knowledge, acquiring new capabilities and producing intelligent human resource pool. Indian Higher Education system has to address itself to global challenges through channelization and maintain the right balance between the need and the demand. [19]

Engineering education, therefore, needs to be looked into as a long-term social investment for the promotion of economic growth, cultural development, social cohesion, equity and justice.

In order to meet the aim, deliberated in the 11th Plan document of inclusive growth and assurance towards genuine endogenous and sustainable development along with social justice and equity, the higher education sector has to play a pivotal role, especially in generating research-based knowledge and developing a critical mass of skilled, educated and value oriented personnel with strong cultural moorings and more importantly a good citizen. [20]

Some of the issues pertaining to the higher education including engineering education system have to be seriously addressed to for the balanced development of higher education / engineering education in India within this philosophical paradigm.

Quality would mainly depend on the quality of all its facets, be it the faculty, staff, students, infrastructure, or administration. As such, all the policies, systems and processes should be clearly directed towards attaining improvements in all the relevant facets for the overall rise in the quality of education. [21]

In order to facilitate the growth of excellence in engineering education, the programs and processes need to be developed with due emphasis to their appropriate monitoring. It includes development of multi-skills and transforming learning patterns, application of information and communication technology (ICT) in quality framework, improvement of external assessment systems and development of internal systems of quality assurance.

4. INTERNATIONAL SCENARIO:

USA produces around 60,000 engineers in a year. [22] The quality of education received by the engineering students from the institutes will have a direct impact and would then contribute to the global economy. Moreover, in the new economy, technological innovation is central to wealth creation and economic growth. [23]

The annual output of engineering students is dominated by the three main countries namely USA, China and Japan in the year 1992. In this same year The European Union (UK) is second only to the Germany in numbers of engineering graduates.
Over the past decades the percentage of engineering degree has fallen from 11 to 6 in the UK for its home students but the total student entrant in engineering degree has increased by nearly 20%. [24]

The total number of engineering and science degree students in different countries is given in figure 1. The maximum strength is in China followed by Japan, America and others countries. [24]

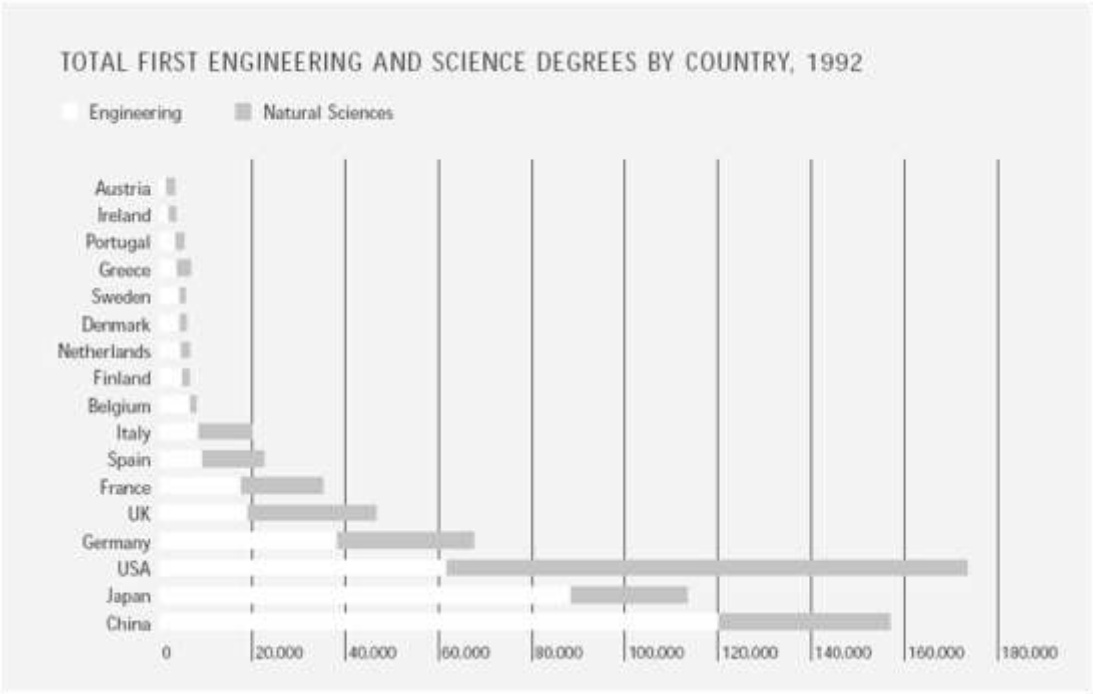

Fig. 1. Total Engineering and Science Degrees by Country.

The number of graduate engineers produced in per million populations for different countries for most recent years is shown in figure 2.
The strength of graduate engineers (per million populations) is maximum (that is 1344) for South Korea in 2002 while in India only 214 graduate engineers per million population is produced in the year 2006. [25]

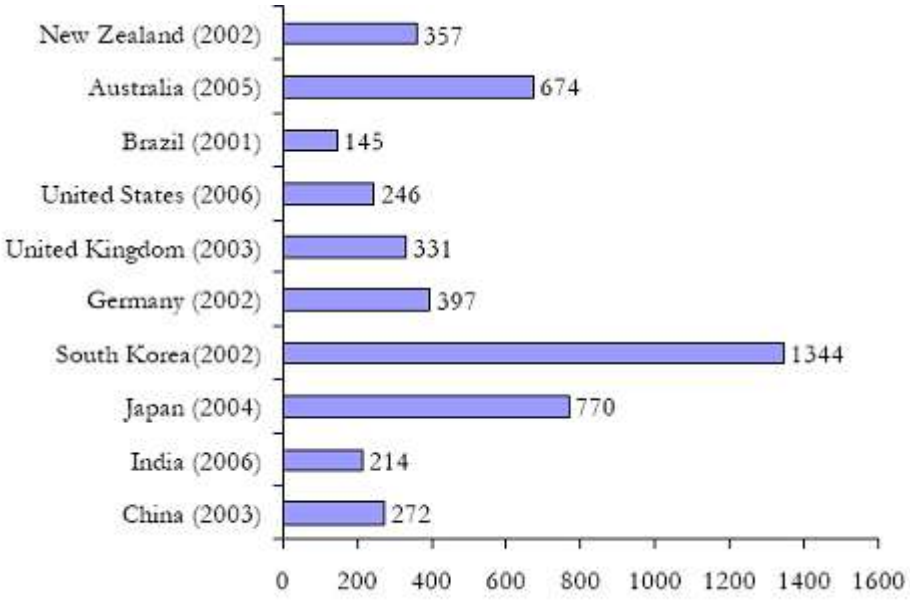

Fig. 2. Engineers per Million Population for different Country.

According to an article published in The Economist, higher education is already a global business. The days when higher education was a matter of national policy and government regulation are rapidly fading. Education is a trillion Dollar industry worldwide. Education industry groups are, therefore, attracted by the prospects of liberalization and globalization. [26]

5. INDIAN SCENARIO:

India has achieved 8-9 percent growth rate per annum in the recent years. However, in terms of Human Development Index (HDI: index measures the average achievements in a country in three basic dimensions of human development namely longevity, knowledge, and a decent standard of living). The real Gross Domestic Product (GDP) per capita India's ranking at 132. In terms of per capita income, India's rank is 126th. [27]

The Economic Survey of 2008-09 argues that this difference is attributable to poor attainment in education. This apparent disjunction between growth rate and our dismal performance in socio-economic indicators particularly in education has become more serious than ever before as income growth along with disparities and discontentment grow in tandem. [28]

The employability of the labour force is very poor and the skill possessed by the workforce is at a very low level. [29]

Based on Annual Technical Manpower Reviews (ATMRs) it is estimated that about 30% of the fresh engineering graduates are unemployed even one year after graduation. Several industry leaders complain about the shortage of quality in engineering graduates. [30]

The funding level for education as a whole is far below the recommended 6 % of national income, as budget for higher education is well below 1%. The share of private sector education in higher education in terms of enrolment is nearly half. [29]

It is also being felt that higher education has to play a key role if India has to meaningfully integrate with the emerging global knowledge economy and achieve inclusive growth as per the mandate of the 11th Five Year Plan. [20]

Fig.3 shows the region wise distribution of Degree (engineering) institution and Fig.4 shows region wise distribution of intake in engineering degree. It is clear from the figure that the southern region is having maximum number of institution amounting to 503 followed by south-west region which is 206. [31]

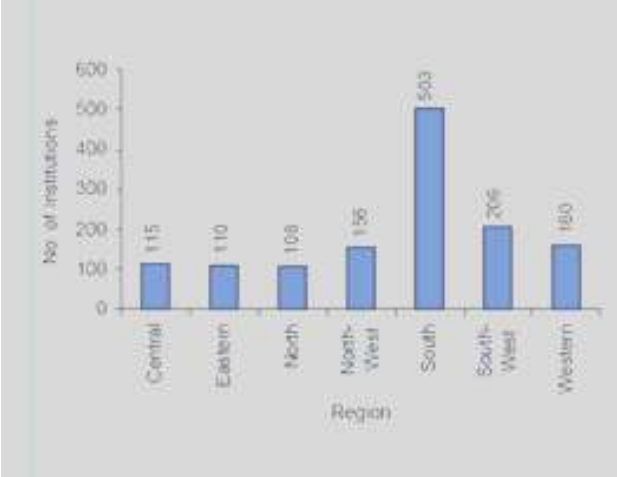

Fig.3. Region wise Distribution of Degree (engineering) Institution

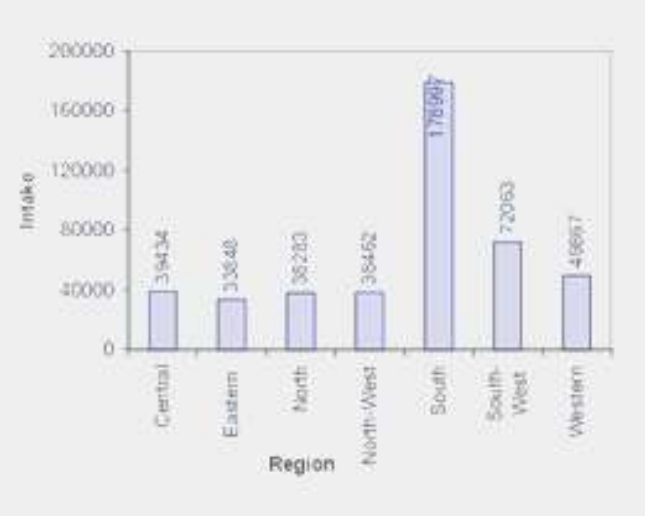

Fig.4. Region wise Distribution of intake in Engineering Degree.

Sector wise Plan and Non-plan budget expenditure from 1993-2005 is given for all sectors of education in Table .1. The expenditure on higher and technical education sector rose from 4122 thousand crore in 1993 to 12949 thousand crore in 2005. [31]

Table-1
Sector-wise Plan and Non-plan Budgeted Expenditure for Education Departments of State and Center (Revenue Account)

Year	Budgeted expenditure in crore of rupees.		
	Higher education	Technical education	Higher + technical
1993-94	3104	1018	4122
1994-95	3525	1189	4714
1995-96	3871	1290	5161
1996-97	4288	1450	5738
1997-98	4859	1623	6482
1998-99	6117	2073	8190
1999-2000	8248	2459	10707
2000-01	9195	2528	11723
2001-02	8087	2560	10647
2002-03	8859	2820	11679
2003-04	9380	3138	12518
2004-05	9562	3387	12949

Source: Analysis of Budgeted Expenditure on Education, MHRD, Government of India, Various years.

The central plan allocation and expenditure during Xth plan is given in Table 2. It is clear from the table that the university and higher education scheme is having 7% of share to the total expenditure. [29]

Table-2
Central Plan Allocation and Expenditure during Tenth Plan (Rs in Crore)

Scheme	Tenth plan allocation	Tenth Expenditure	% to total
University and higher	4176.5	4246.3	7
Technical education	4700	3453.79	6

Source: Annual Financial Statics of Education Sector 2003-04, MHRD, Government of India, 2005 and expenditure budget 2006-07, Volume-2, Government of India, February, 2006.

Table-3 shows the growth of universities in Xth plan. The total is about 203 including the Central, States, Deemed and Private ones. [31]

Table-3
Growth of Universities in Tenth plan (4 years only)

S.No.	Category	As on 31-3-2002	As on 31-3-2006	Universities funded by UGC	Directly by Central Government

1	Central	18	20	18	2
2	State	178	217	158	-
3	Deemed	52	104	25	-
4	Institutes (Established by state legislative Act)	05	05	03	-
5	Institutions of national importance (Established by Central Legislation)	12	13	-	13
6	Private University	-	8	1	-
	Total	265	367	205	15

Source: UGC.

Table-4 shows the enrolment of students in major disciplines. It is clear that the enrolment has total higher degree education (excluding diploma) has increased from 2442453 in 1980-81 to 10009148 in 2003-2004. Out of which the technical graduates are only 239267 in 1980-81 to 1110840 in 2003-04. [31]

Table-4
Enrolment by Levels and Major Disciplines

Year	PhD	PG	General Graduates (Art, Science and Commerce)	Technical graduates (Engineering, medical, B.Ed.)	Total Higher Education
1980-81	25417	291341	1886428	239267	2442453
1990-91	32468	354216	3285776	416828	4089288
2000-01	45004	647338	7244915	688625	8625882
2001-02	53119	647016	7139497	790050	8629682
2002-03	65357	782590	7633125	1035701	9516773
2003-04	65525	806636	8026147	1110840	10009148

Source: Selected Educational Statistics, Different Years.

Table-5 shows the state wise distribution of India's technical training institutions.[32]

Table-5
India's Technical Training Institutions

	Arts, Science and Commerce	Engineering and Architecture	Teacher Training Colleges
India	11,699	1,567	1,669

Source: Ministry of Human Resource Development, Government of India.

6. PUBLIC EXPENDITURE ON HIGHER EDUCATION / ENGINEERING EDUCATION IN INDIA:

India has developed one of the largest systems of Higher Education in the world with over 230 universities and 6500 vocational colleges catering to about 10 million students. Most of these are publicly funded although some may be privately run. [32]

All India Council for Technical Education (AICTE) in its report has concluded that India has made enormous strides in its economic and social development in the past two decades. It further states that it needs to make its education more 'demand driven' to meet the emerging needs of the economy and to keep its highly qualified people within the country. The Report further emphasises on, India's need to maintain and enhance its competitive advantage of abundant, high quality and cost effective human resource. It also says that it needs to ensure the right mix of technical, business and functional skills in the work place to meet the needs of individual business segments. [33]

A recent government report finds two-thirds of India's colleges and universities below standard. India's highest-quality institutions have severely limited capacity. According to the New York Times, 320,000 students took the IIT entrance exam in 2008 even though only 8,000 slots were available. [33]

According to AICTE report it is stated that second tier engineering institutions produced around 207,000 graduates in 2005 while IITs produce 3000 engineers only. Most of the second tier institutions are privately owned accounting for about 84 percent of the total seats. However employers many a times criticize these second tier institutions and also to some extent even to top schools for paying insufficient heed to the skills needed in the workplace and the pedagogical techniques that reward innovation. Further, in India only 4 percent of research expenditure is made through universities while in US it is 17 percent and in Germany it is 13 percent whereas Chinese research expenditure in man power is estimated at 708 researchers per million people which are six times that of India. [34]

In present times, education has become a mass phenomenon in India. The load on education system has become very high but the policies and procedures related to admission, teaching, infrastructure and examination have been streamlined but not uniformly streamlined to handle this vast load. Despite the best efforts, government bodies like Directorate of Technical Education of various states, AICTE and universities have not been able to achieve much in maintaining desired quality standards. [35]

External interference in all aspects of education such as admission policy, teaching process, faculty selection and examination system etc have played vital role in deterioration of quality of education. In order to produce efficient manpower of right quality, it is extremely important that all policies and procedures relevant to technical and engineering education are standardized and their variations from one institution to another are substantially removed.

Technical education being a national issue, it is necessary that technical education in the country is driven by common policy. [36]

The public-private partnership is also being advocated in view of the perennial fiscal crunch and misplaced faith reposed on the private sector under the rhetoric of efficiency gain. However, the rationale behind any policy has to be judged in the context of the socio-economic conditions that prevail in the country today. The policy is expected to have the backing of an appropriate theoretical framework also. [37]

It is essential that the regulatory system propel the growth in the right direction. A well-designed regulatory system will also help to promote a high degree of professionalism in managing higher education institutions. Therefore, it is important to design a balanced and all encompassing regulatory mechanism that is Overreaching, transparent and ensures accountability which would evoke confidence in the academic institutions and academic body at large. [36]

This can be achieved to some extent by way of accreditation. The primary purpose of accreditation is to ensure quality control and quality assurance, commonly with reference to a certification system in the areas of education, training, testing, etc. In some countries, this function is performed by an agency of the Ministry of Education, while in several industrialized countries it is undertaken by a confederation of voluntary agencies or professional societies. [38]

The Accreditation Board for Engineering and Technology, ABET, has been the pioneer in designing and implementing the accreditation of engineering and engineering technology programs in the US. Several countries world-wide have followed closely the ABET processes. The Indian initiative, through the establishment of the National Board of Accreditation in 1994, has derived inspiration from the rich experience of ABET, but has introduced several modifications appropriately to take local conditions into account. [39]

In order to evaluate performance of an institution and bring about a measure of accountability a mechanism of accreditation has been developed by UGC. This is an autonomous council under UGC called National Accreditation and Assessment Council (NAAC) with a purpose to carry out periodic assessment of universities and colleges. NAAC has evolved a methodology of assessment which involves self-appraisal by each university/college and an assessment of the performance by an expert committee. [40]

Similarly, for technical education AICTE has established its own accreditation mechanism for its institutions through the National Board of Accreditation (NBA). NBA has also undertaken a detailed exercise for bench marking the performance of reference for evaluation. However, both NAAC and NBA are in the right direction so far only 47 universities, 75 affiliate college and 20 autonomous colleges have volunteered to be accredited by NAAC. Some more universities and 25 more colleges are in advanced stage of

finalizing self-study reports. There is a need to link up the grants and loans to NAAC and NBC reports. [41]

Similarly, for technical education AICTE has established its own accreditation mechanism for its institutions through the National Board of Accreditation (NBA). NBA has also undertaken a detailed exercise for bench marking the performance of reference for evaluation. However, both NAAC and NBA are in the right direction so far only 128 Universities and 2879 Colleges across 28 states of the country as on 21 May, 2006 have volunteered to be accredited by NAAC. [41]

7. BRIEF REVIEW:

A brief review on some relevant aspects and issues of quality in higher and higher engineering education is presented in this section.

Marvin E. Gonzalez, Gioconda Quesada, Kent Gourdin and Mark Hartley [42] in their paper have utilized benchmark analysis and quality function deployment (QFD) to develop a customer oriented under graduate curriculum in supply chain management.

Adkins and Radtke [43], and Clayson and Haley [44] have indicated in their respective papers the problems that are faced in higher education program. The lack of emphasis on real decision making tools seems to be missing. They also observed that oral and written communication skills are not covered well in such higher engineering education program.

Bhagwan Shree Ram and M. Selvaraj [45] have identified the required skills for sustainable employment for engineering graduates. According to their findings the students with skills like positive attitude, effective communication, problem solving, time management, team spirit, self confidence, handling criticism, and flexibility have much more better chances of survival in the tough corporate world.

Anil R. Sahu, R. L. Shrivastava, and R. R. Shrivastava [46] in their paper have attempted to develop a mathematical model to measure effectiveness of technical education in India. They have also studied in detail the factors affecting the effectiveness of technical education. This is given in Table -5

TABLE-5 Input Factors Affecting Effectiveness for Total Quality in Technical Education

Authors	Factors affecting effectiveness
K. B. Powar & S. K. Panda [47]	Course validation, course review, audit, inspection, moderation, performance indicators and accreditation.

Sangeeta Sahney et al.[48]	Identify the different customer and their requirement, expectation and requirement of a customer. Student perspective and administrative staff perspective, Physical facilities and infrastructure.
Ahuja I.P.S. and Singh T. P.[49]	Curriculum development in emerging technologies, faculty development, modernization and better utilization of infrastructural facilities, enhanced exposure of students to industries, feedback system, autonomy to technical institutions. fostering / promotion of research aptitude in graduates, networking between institutions, institution-industry interaction, accreditation of institutions, resource mobilization and continuing education programs.
Roma Mitra et al.[50]	infrastructure, faculty, curriculum, stakeholder and system and policies.
P.B.Sakthivel,[51, 52]	commitment of top management and leadership. customer focus, course delivery, communication, campus facilities, congenial assessment and improvement
Surendra V. Gole, Dhanjay Jolhe[53]	knowledge, skill, performance and behaviour.

Sushma kulkarni[54]	customers, governments, other industries, funding agencies and public.
Mallesham P[55]	The quality of technical education system depends on the institution, vision, mission long range goals, short range goals, infrastructure, faculty's research and development activities and industry-institutions interaction , curriculum, examination and evolution system, students, placement and consultancy etc.

Lav R Varshney [56] in his article has discussed at length the importance of accreditation in engineering institutions to increase its quality to suitable level.

Tad Stephen Anderson, Elizabeth K. Michael, and James Jeffrey Peirce [57] in their study have discussed that in spite of its complexity every public-private- academic partnership can be successful if certain needed steps are taken for big science and technology.

Gary Rhoades and Barbara Sporn [58] have studied globalization in terms of the diffusion of quality assurance model and practices between two core regions, the US and Europe, specifically for strategic management practices in higher education.

Charles E. Harris [59] has advocated the universalization of the code of ethics of internationally recognized engineering society of mechanical engineering like ASME-International. He has identified nine guidelines and some methods of applying the code to some specific condition. He underlines 3 such methods namely specification, balancing and finding a middle way.

Kin Wai Michael Siu [60] while discussing the need to nurture the engineering and production designer using Hong-Kong as a case study proposes a consideration of 8Cs for engineering and product design curriculum namely competent, comprehensive, compulsory, critical, creative, curious, collaborative and continuous.

S. Prakasam et. al. discussed the importance of the internet in the education system. According to them the growth of internet has created new ways for education it also helps to the learners and the teachers to realize their pedagogic activities with less effort, time and money [61].

According to Nikos Avradinis et al. the introduction of technologies such as multimedia and the World Wide Web evolve the importance of educational software over the past few years. These innovations have offered in the field of computer-based instruction, by providing the means for remote, interactive and intuitive applications. [62]

L Tamie et al. discussed the importance of simulation tools to help students to model a system, understand it, and then explore alternate designs. The disadvantages of the traditional simulation software are its expense, lack of portability and long learning curve. According to them World Wide Web (WWW) simulation has the potential to overcome with these limitations. Benefits of WWW-based simulation include wide accessibility, controlled access, efficient maintenance and increased integration. [63]

From the above discussion it is clear that the engineering education system is a large system containing number of elements. Study (Modelling) of such large systems requires high level of expertise to properly identify and represent complex interrelationships between various elements of the concern system.

Further, engineering education system has a number of structures associated with it and deals with a lot of challenges, such as the changeable and progressive industrial scenarios, changeable client perspectives and expectations, and variability of legal and normative situation from one place to another. [64] These challenges make engineering education system complex to address.

The power of certain soft system methodologies have been advocated by proponents of interactive management and systems engineering to address issues related with complex systems. [65], [66]

Prem Saran Satsangi in his editorial review articulated the importance of Nominal Group Technique (NGT) and Interpretive Structural Modelling (ISM) to address the complex environment. According to him very large variety of the environment as well as the smaller but still considerably large variety of the system itself are appropriately attenuated by the study through consensus-driven Nominal Group Technique (NGT) and ISM. [67]

According to Linstone et al. Delphi method can be characterized as a technique for structuring a group communication process so that the process is effective in allowing a group of individuals, as a whole, to deal with a complex problem [68].

Ammeret Rossouw, Michael Hacker, and Marc J. de Vries [69] have conducted a Delphi study among experts for finding key concepts to be taught in engineering and technical education.

F. R. Janes [70] while discussing the importance of ISM techniques states that it (ISM) combines three modelling languages: words, digraphs and discrete mathematics, to offer a methodology for structuring complex issues. It readily incorporates elements measured on ordinal scales of measurement and thus provides a modelling approach which permits

qualitative factors to be retained as an integral part of the model. In this it differs significantly from many traditional modelling approaches which can only cope with quantifiable variables.

According to A.K. Madan et al. [71] the interpretive structural modelling is a possible solution for modelling of various parameters to rank them as per criticality for improvement in quality of technical education.

Alexia Georgakopoulos discussed in his paper the challenges of teacher effectiveness and uses a systems approach to investigate teacher effectiveness as a multi-dimensional, holistic phenomenon. He uses Nominal Group Technique and Interpretive Structural Modelling to construct structures to assist students. The study points to the importance of ongoing faculty development in teacher effectiveness. [72]

Fuzzy cognitive maps have also been used to represent mental beliefs of an underlined elements of a complex system graphically following a set of discursive representation from one's own cognitive representation on a particular subject to help one to think about the presented reality. These have been used to model strategies of various systems like industries, solid waste management etc. [73], [74], [75]

The above exposition shows the importance of critical systems thinking to address the challenges of problems characterized by large scale, complexity, uncertainty, and subjectivity. However, an integrated use of these consensus driven interactive – iterative processes to develop models / strategies for higher engineering education to achieve global competence is still lacking.

7. PROPOSAL FOR THE PRESENT WORK:

The above facts reveal that there is a strong need for quality assurance initiatives to be developed and carried out for almost every engineering institution whether second tier or otherwise to bring quality at a common qualifying scale. It is also needed that industry institute interaction at academic level be made necessary for almost every type of industry so that their market requirement for the type of needed skill and technovation in the workplace is assured to some extent. At government level sufficient control through appropriate strategic planning is instituted to provide sufficient budget allocations for research work of minor as well as major level. Further such research works should be aptly monitored and supported for its real life application. It is only then that the engineering institution of India would initially be competitive locally and may achieve global competence later.

It, therefore, seems imminent in view of the above revelations that some strategies be modelled as a common yardstick so that engineering institutions be categorised and ranked for global competence at different levels of socio-economic and industrial requirements to help manage system of higher engineering education intelligently to meet the challenges of global competence.

To meet the above requirements the following steps are expected to be explored:

1. To identify descriptive elements for higher engineering education system in India at various sub-system level to meet the challenges of global competence.
2. To integrate these elements using some consensus driven methodology for its relevant convergence. (Consensus driven methodologies like NGT and others will be used).
3. To evolve normative elements for higher engineering education in India for global competence to explore the possibility of objectives, threats and solutions thereof in order to develop an action plan. Idea Engineering, Nominal Group Techniques and Delphi / Fuzzy Delphi can be possible tools.
4. To develop integrated structural model of identified descriptive elements and to generate relevant alternative structures for identified mission objective / objective. Option Field Methodology and Option Profile Methodology can be exploited.
5. To develop causal relationship and relevant strategies using the concept of fuzzy cognitive map / concept map.
6. To develop integrated model for identified integrated quality elements to evaluate the level of performance of engineering institutions and departments and other sub-systems, if possible. The concept of Fuzzy decision methodology will be exploited to develop such model for evaluating level of quality.
7. To fine tune the developed model using some appropriate methods to find an optimal strategy.
8. To validate the above model using amenable tool / tools.

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